

Human-in the-Loop Simulation in ATM

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Knowledge for Tomorrow



Outline

- DLR Institute of Flight Guidance
- Modell and Simulation
- Validation and EOCVM Framework
- Project EMMA2
- Exercise using Structured Planning Framework for Human-in-the-loop Simulations



DLR - German Aerospace Center

- Approx. 8000 employees across 33 institutes and facilities at 16 sites:

- Offices in

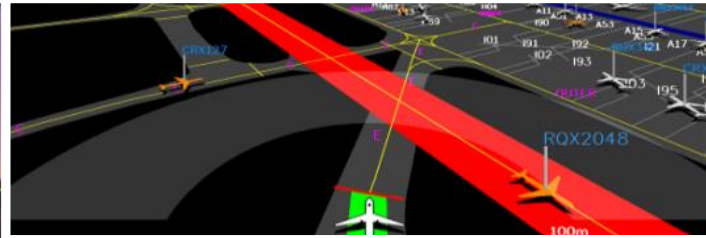
- Washington D.C.
- Brussels
- Paris
- Tokyo



Institute of Flight Guidance

- Director Prof. Dr.-Ing. Dirk Kügler
- Main Research Topics
 - Air Traffic Management (ATM)
 - Airport Operations and Surface Management
 - Unmanned Aerial Systems
 - Human-centered Automation
 - Validation Methodology
- Departments
 - Air Transportation
 - Pilot Assistance
 - Controller Assistance
 - ATM Simulation
 - Human Factors

DLR Institute of Flight Guidance



DLR Institute of Flight Guidance: Success Stories

from visions and first ideas to implementations and deployment

- Remote Tower

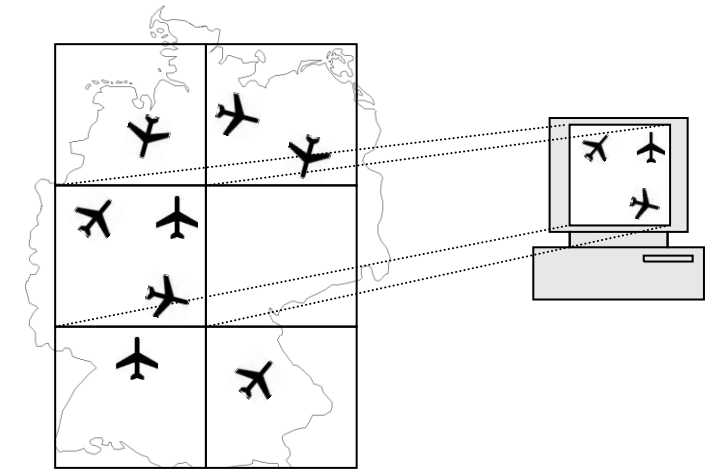
RApTO_r 2005-2008



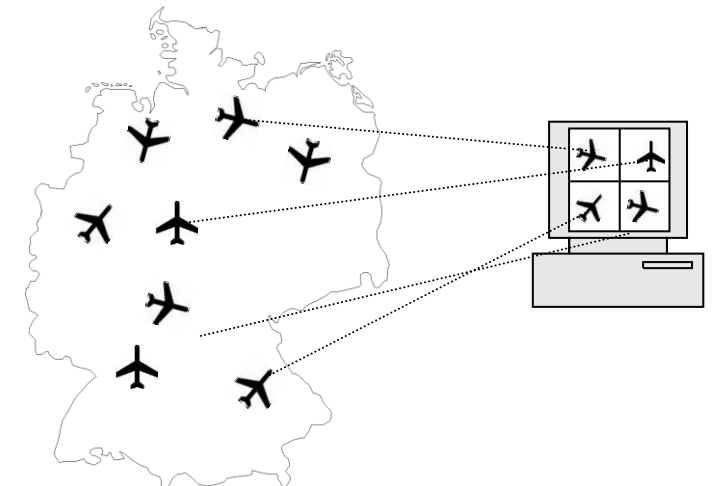
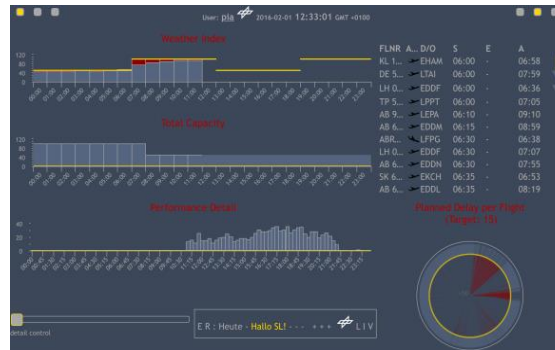
SESAR 2012-2015



- Sectorless ATC

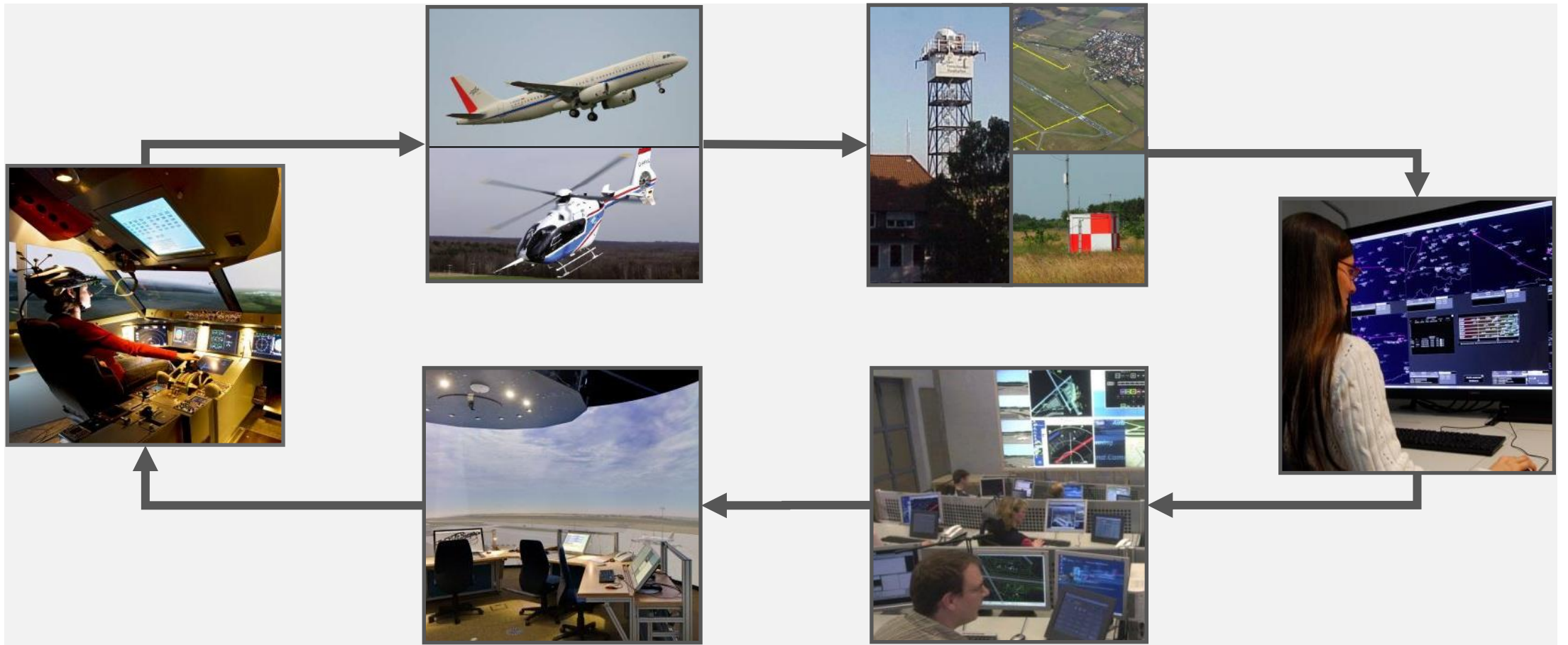


- Total Airport Management



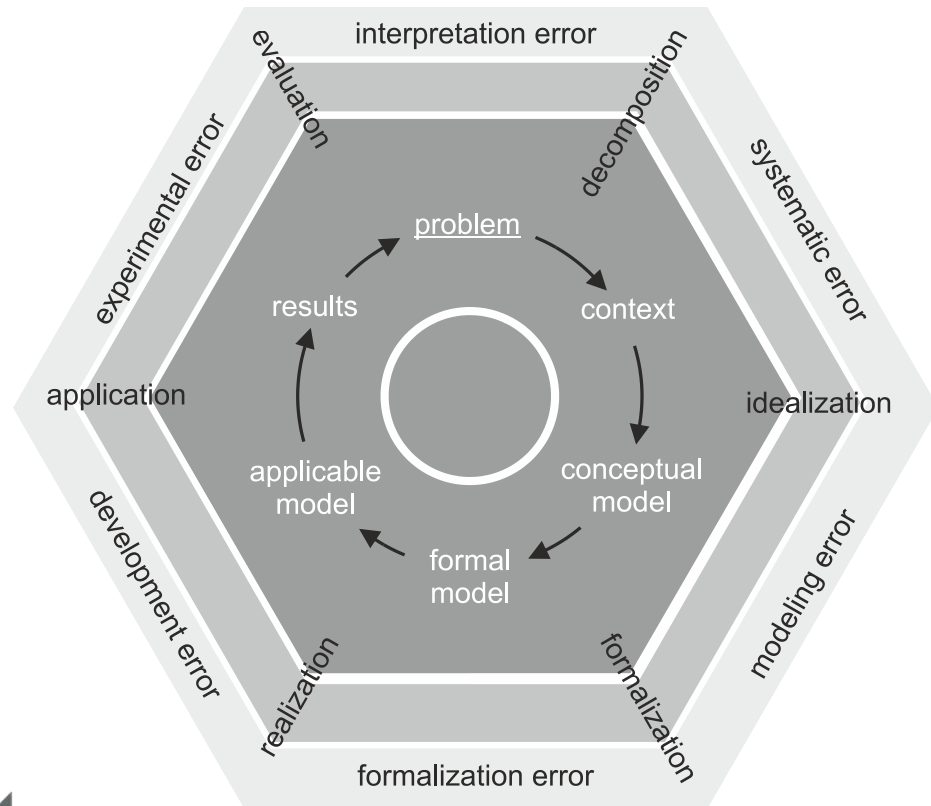
Air Traffic Validation Center

flexible connect research facilities – test, validate, evaluate system wide

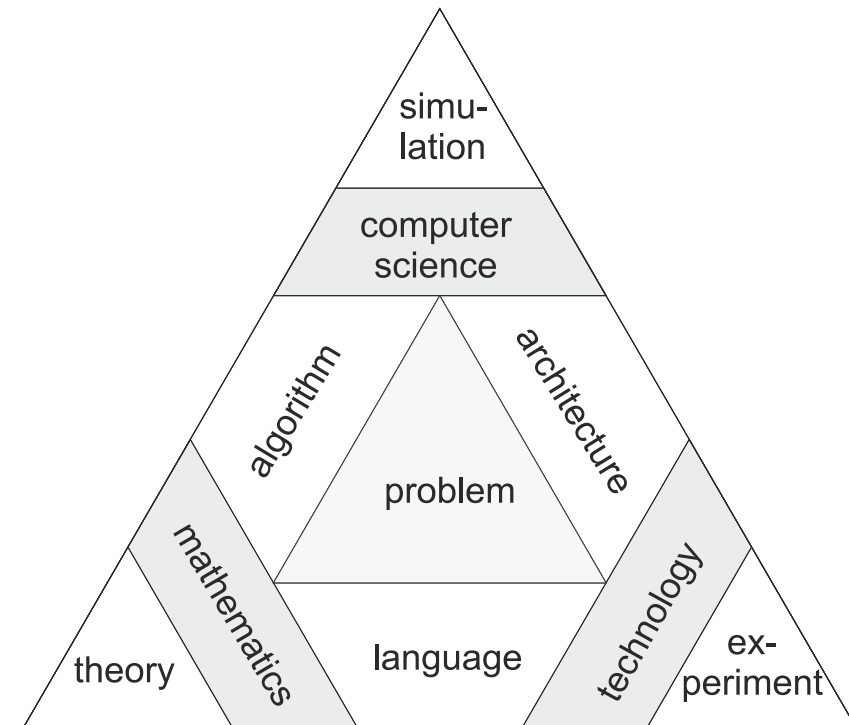


Modelling and Simulation

- Modelling as problem driven approach using an appropriate reduced copy of the reality systematically reflecting required constraints



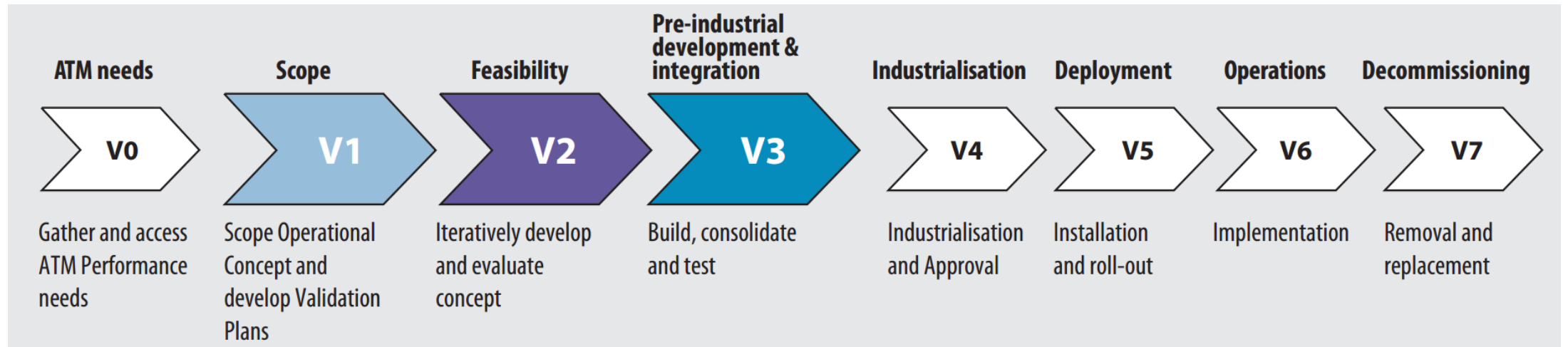
- Simulation as part of Computational Science and Engineering (mathematical models, computer implementation and visualization)



[<http://nbn-resolving.de/urn:nbn:de:bsz:14-qucosa-85592>, pp. 7]]

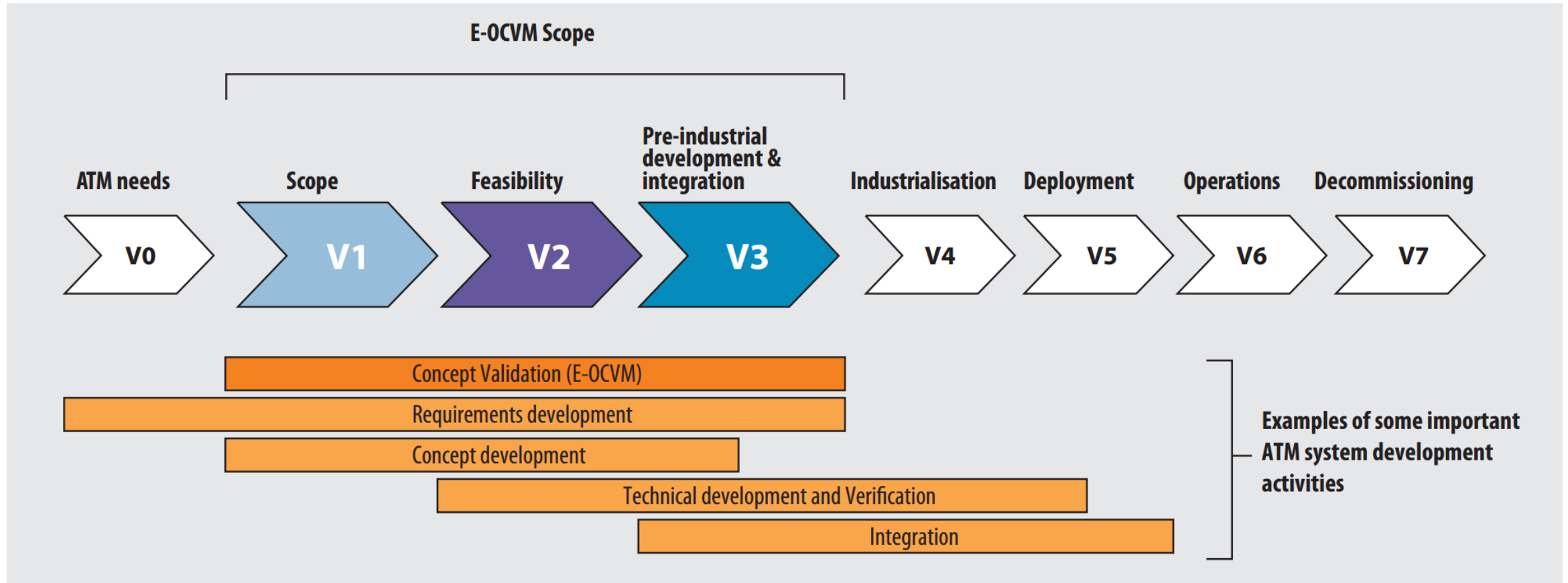
E-OCVM - European Operational Concept Validation Methodology

concept lifecycle model



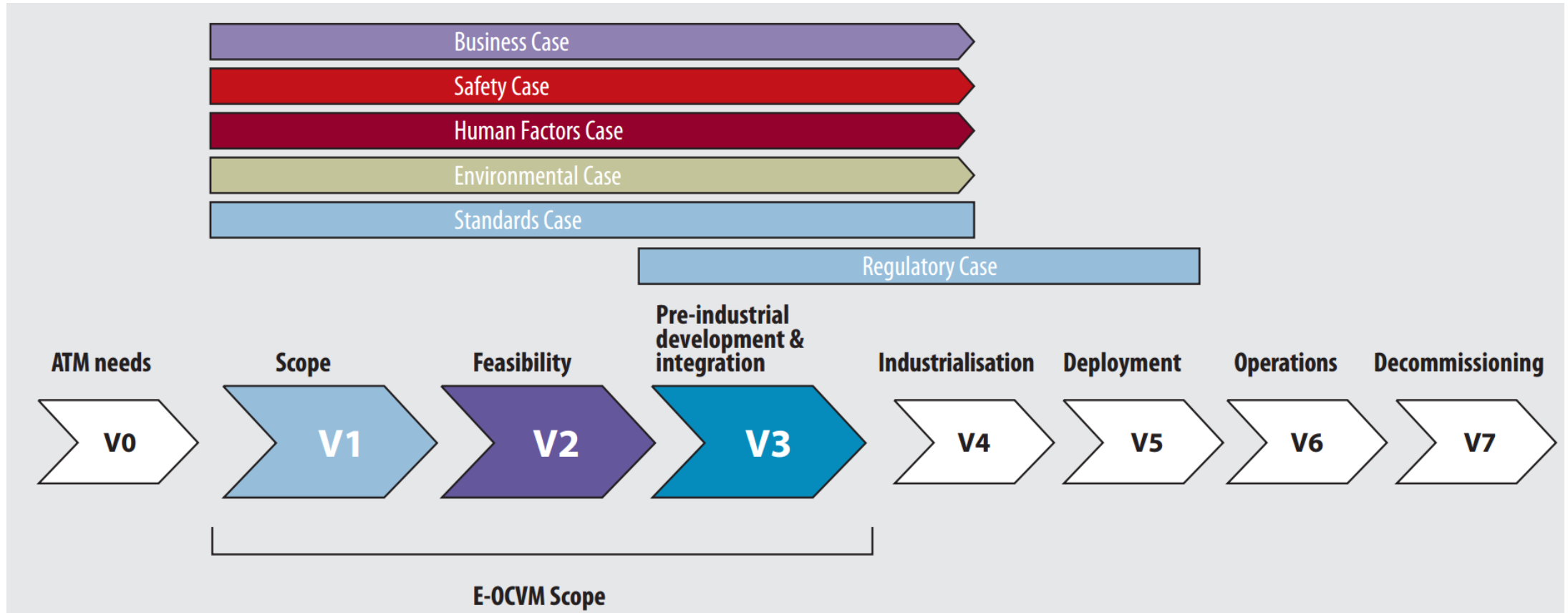
E-OCVM

validation and ATM system development activities



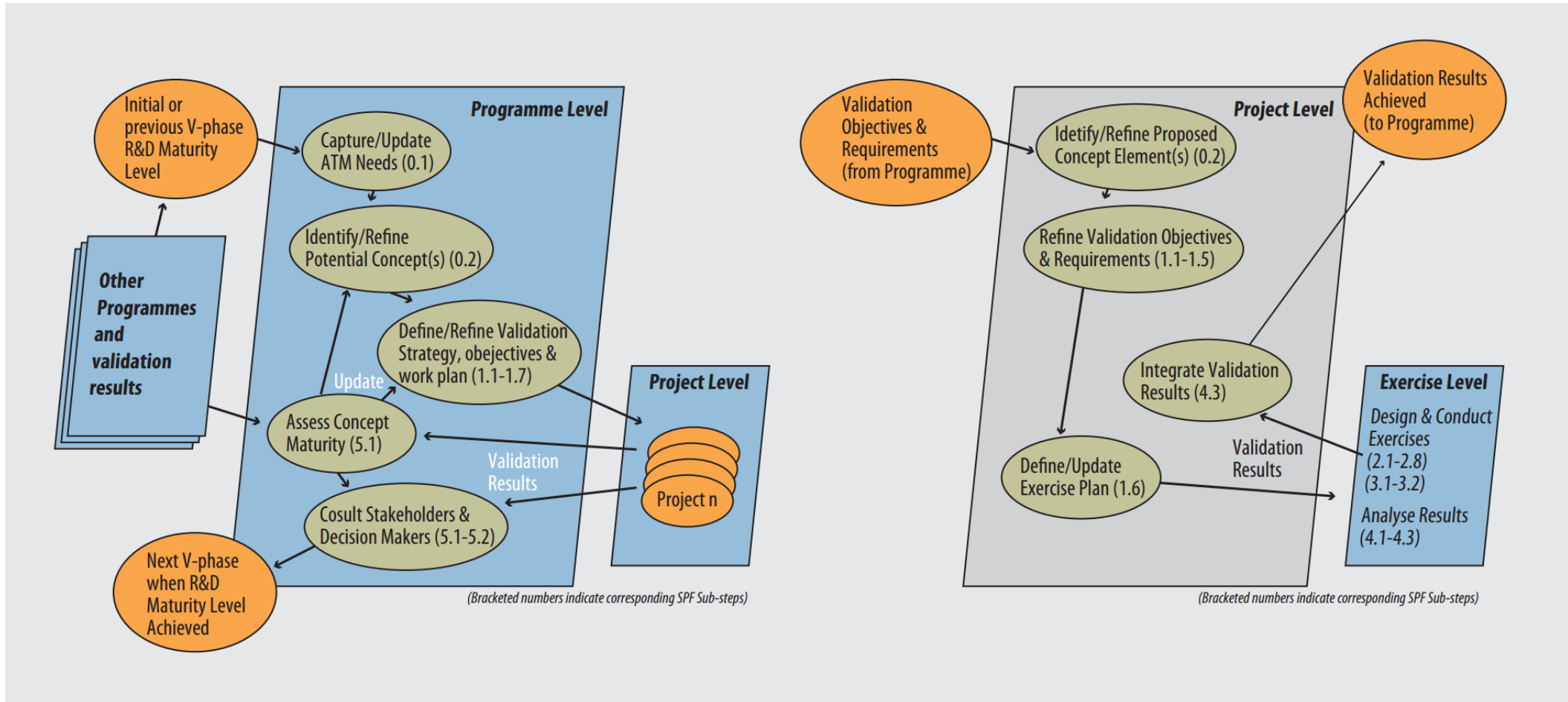
E-OCVM

scope on different cases



E-OCVM

structured planning framework - activity level: programme, project or exercise



Example

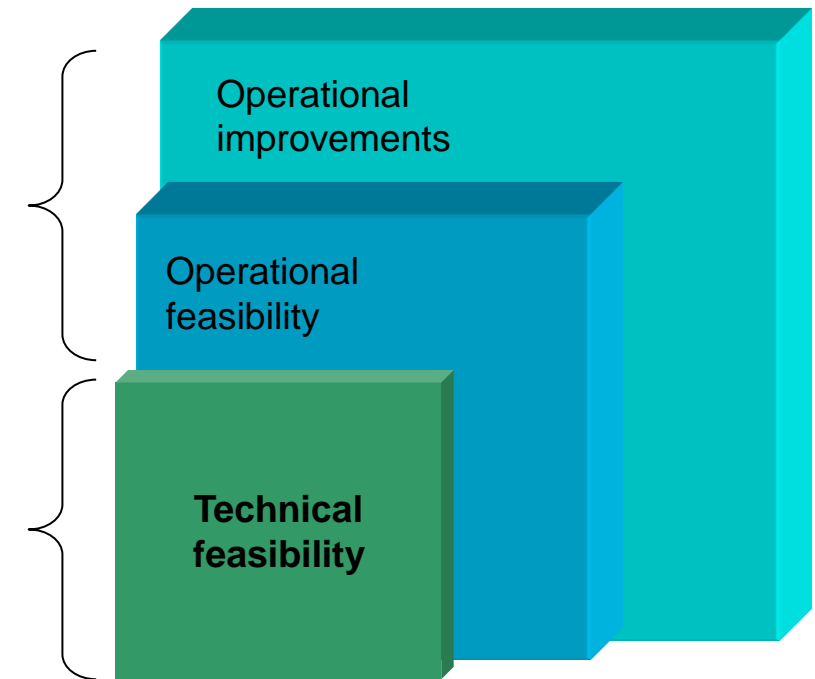
EMMA2 - European Airport Movement Management by A-SMGCS, Part 2

- Cornerstones
 - operational concept for all A-SMGCS levels
 - derive necessary performance requirements
 - A-SMGCS integration (airports and aircraft)
 - two iterative test periods
 - verification of performance requirements
 - validation of operations
- Goal
 - **Guidelines** and **recommendations** to common technical and operational system performance, safety requirements, certification aspects, and procedures for the transition phase.

- Focus - validation chain

Validation:
Did we build
the right system?

Verification:
Did we build
the system right?

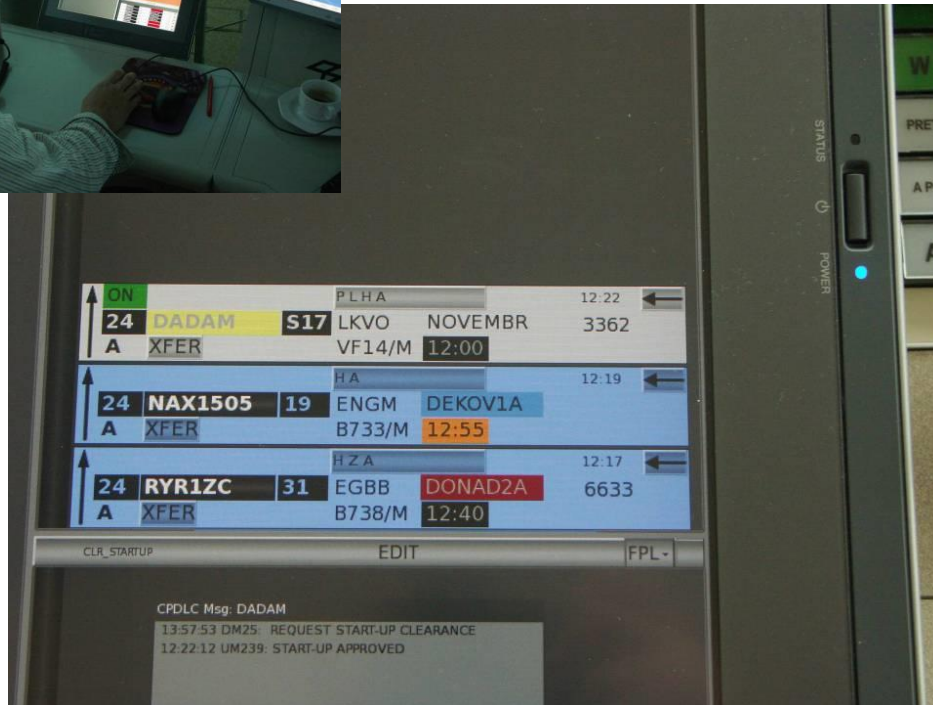


Exercise

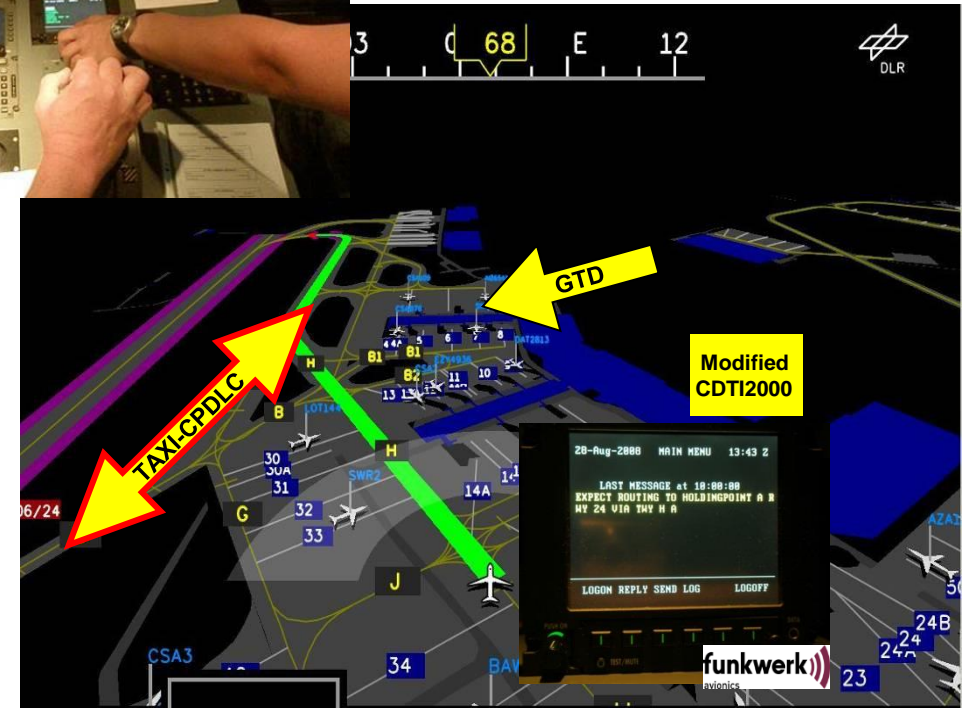
EMMA2 technologies/procedures to be tested



- Controller
Electronic Flight Strips



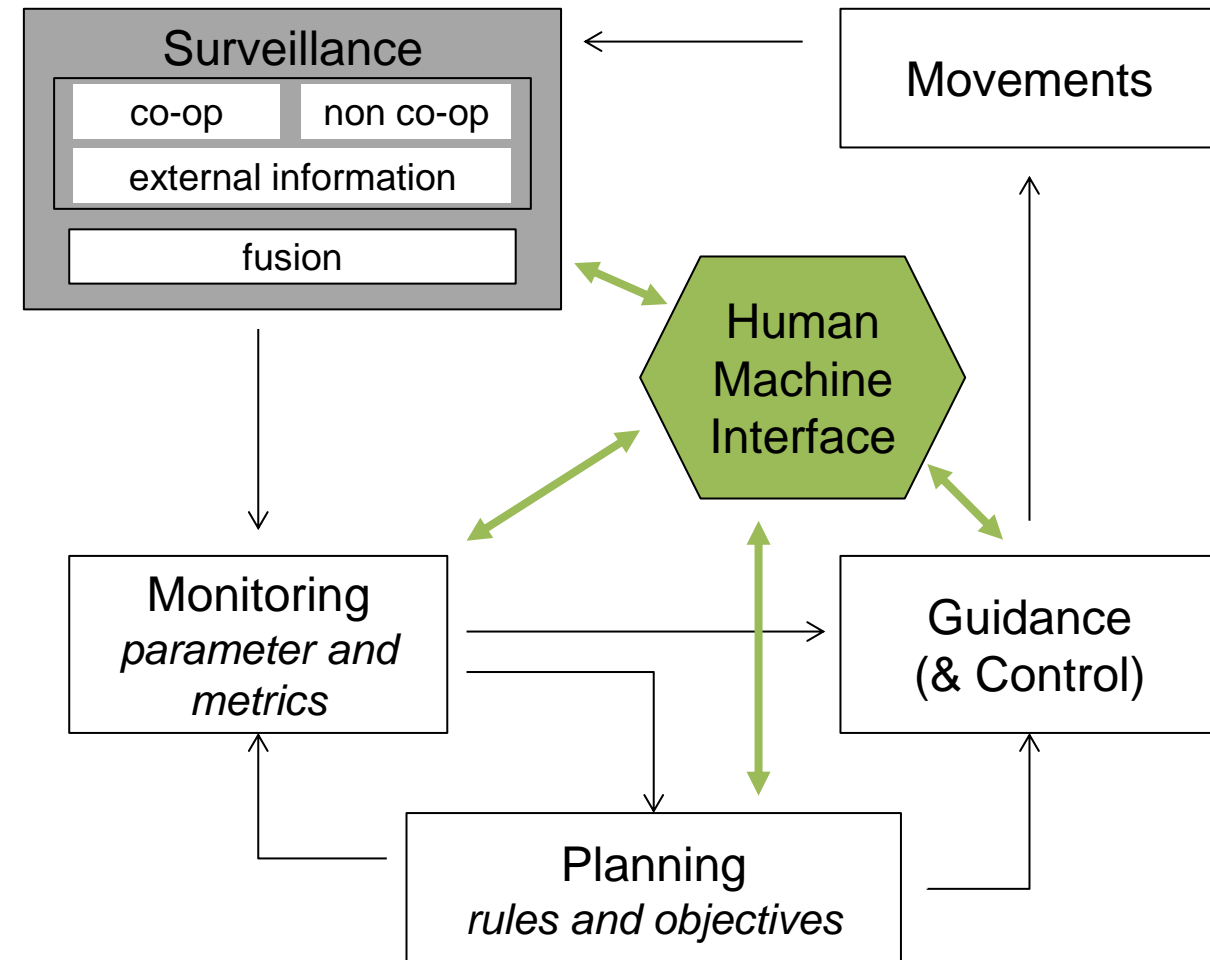
- Pilot
Electronic Moving Map



Exercise

How to plan EMMA2 Human-in-the-loop simulator studies?

- Project Level
 - Identify/Refine proposed concept elements (0.2)
 - Refine validation objectives and requirements (1.3-1.6)
 - Define/update exercise plan (1.6)
 - *Integrate validation results ← exercise level*
- Exercise Level
 - Design and conduct exercises (2.1-2.8, 3.1-3.2)
 - Analyze results (4.1-4.3)
 - *Deliver to project level → validation results*



Example EMMA2

setting the scene for exercise

- Goal: to validate a taxi guidance system consisting of electronic flight strips (EFS), departure manager (DMAN), taxi and controller pilot data link communication (CPDLC), routing and ground traffic display (GTD)
- Environment
 - real-time simulation (RTS) or on site trials (OST)
 - RTS 1: EFS plus DMAN and routing (with controller)
 - Next iteration RTS 2 (incl. lesson learned from RTS 1)
 - field trials
 - coupled validation at tower and cockpit simulation environment (CPDLC, GTD)
- Experimental subjects
 - subject matter experts from investigated airport (local controller and pilots)
- Evaluation, quantification
 - tailored questionnaires to cover all aspects of operational requirements
 - RTS: development of baseline scenario (allows for evaluation of situational awareness, work load)
- Validation plan (more than E-OCVM demands – E-OCVM is a frame work)
- Validation report of all results, evaluation, interpretation, recommendations, follow up



Example

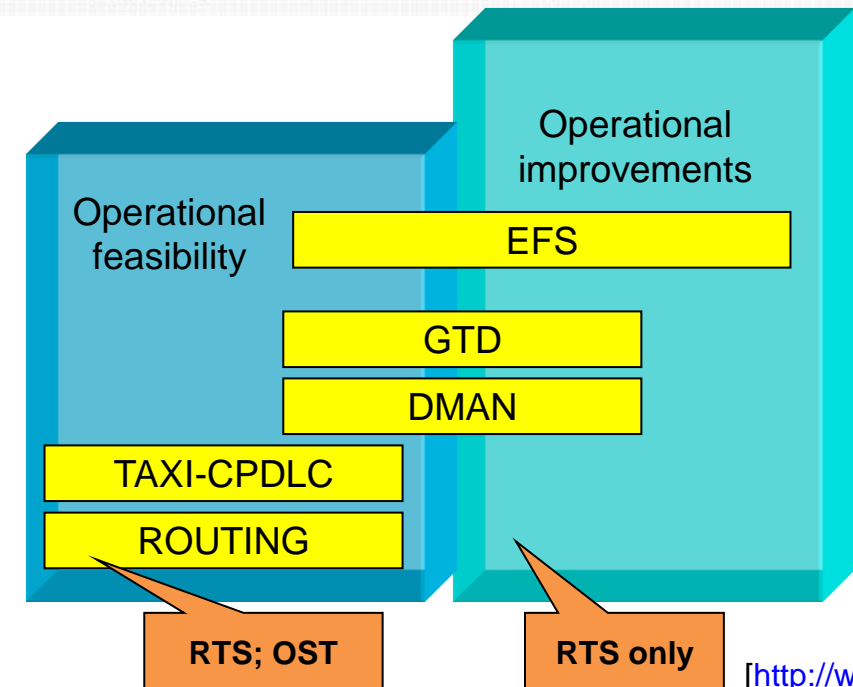
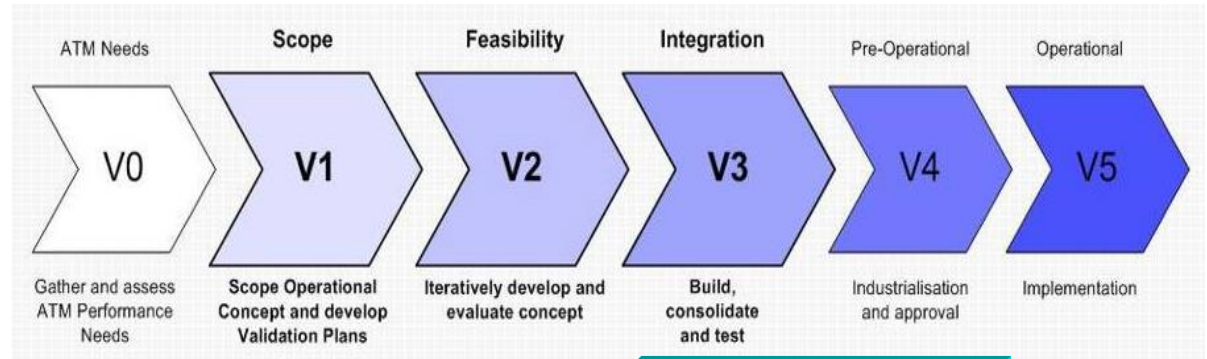
EMMA2 - European Airport Movement Management by A-SMGCS, Part 2

• Cornerstones

- operational concept for all A-SMGCS levels
- derive necessary performance requirements
- A-SMGCS integration (airports and aircraft)
- two iterative test periods
- verification of performance requirements
- validation of operations

• Finally

- Guidelines and recommendations to common technical and operational system performance, safety requirements, certification aspects, and procedures for the transition phase.



[<http://www.dlr.de/emma2/>]

Programme/Project Level

structured planning framework

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3

Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
0. State Concept and Assumptions	0.1	Capture or update the ATM needs.	Survey stakeholders to gather and analyse information on the ATM problem. Identify Key Issues, KPAs and existing performance levels in context of performance framework. Define ATM needs, performance targets and concept performance objectives.		
	0.2	Identify or refine the proposed solution(s).	Draw up and review proposed operational concept(s). Draw up typical operational scenarios and context. Assess alternative solutions.		

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3

Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
1. Set Validation Strategy	1.1	Identify or refine: a) stakeholders; b) the cost and benefit mechanisms.	Formally identify participating stakeholders. Identify potential cost and benefit mechanisms, including the definition of performance objectives.		
	1.2	Identify R&D needs and carry out the initial maturity assessment for each concept.	Carry out the initial maturity assessment to identify the current and target levels of maturity of the concept(s) or concept elements: assess whether at V1, V2, V3... for each starting point. Deliver the R&D needs.		
	1.3	Define the objectives for the validation activity.	Identify what the validation activity is expected to achieve. Will include any case requirements.	Review validation objectives defined for the project and review any ambiguity with the programme management.	
	1.4	Refine the performance objectives.	Refine performance objectives in KPAs, KPIs, and high-level indicators and metrics.	Refine or update detail of indicators at level of project, and show how they relate to the indicators identified by the programme.	
	1.5	Define the validation requirements.	Identify how the validation objectives will be assessed in general terms (e.g. validation infrastructure available, policies).	Identify how the project will conduct its validation activities (i.e. which validation tools and techniques will be applied to which aspects of the problem).	
	1.6	Define or refine the validation work plan.	Break programme into projects and provide project work plan. The breakdown of the operational concept into elements may provide a basis for this activity.	Break project into exercises and provide exercise work plan.	
	1.7	Consolidate the validation strategy (in one document).	Deliver or update the validation strategy.		

[<https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf>]

Exercise Level

focus: human-in-the-loop

- Task: provide answers for sub steps

Step	Sub-Step	Name	Activities – Exercise Level
2. Determine the Exercise Needs	2.1	Identify the acceptance criteria and performance requirements for the exercise.	Identify what is expected of the exercise by the project and how the exercise result contributes to the project result – what does success look like?
	2.2	Refine the validation objectives.	Add detail to the exercise objectives defined by the project, where necessary.
	2.3	Refine exercise validation requirements.	Add detail to the exercise environment defined by the project and specify in detail the methods, platforms etc. that will be used and how. Record assumptions made.
	2.4	Identify indicators and metrics.	Prepare the detailed list of indicators and metrics, showing how they relate back to the project indicators, if applicable.
	2.5	Develop the validation scenarios.	Specify the detailed operational scenarios and justify that they will fulfil the exercise objectives as defined by the project.
	2.6	Produce the validation exercise plan.	Deliver final exercise-level validation plan. Includes analysis specification and detailed exercise design.
	2.7	Prepare material for the exercise.	Prepare exercise environment (exercises, scripts, models, platform, etc.).
	2.8	Conduct pre-exercise testing and training.	Confirm exercise environment. Identify and remove unexpected behaviours and artefacts of study. Confirm that key experimental assumptions seem justified. Train participants (where required).

[<https://www.eurocontrol.int/sites/default/files/publication/files/e-ocvm3-vol-1-022010.pdf>]



Exercise Level

focus: human-in-the-loop

- Task: provide answers for sub steps

Applying the SPF at Programme/Project/Exercise Level to V1-V2-V3					
Step	Sub-Step	Name	Activities – Programme Level	Activities – Project Level	Activities – Exercise Level
3. Conduct the Exercise	3.1	Carry out the validation exercise.			Collect “raw” data. Observe for unexpected behaviours not already addressed pre-exercise.
	3.2	Examine unexpected behaviour or results, and reports of problems.			Study any problem reports, challenges to assumptions and emergent behaviours to determine if they relate to the concept.

4. Analyse the Results	4.1	Analyse the data as planned.			Analyse exercise data.
	4.2	Prepare analysis contributions.			Prepare exercise analysis contributions.
	4.3	Prepare the validation report and cases.	Integrate results of projects. Build programme-level cases reports. Consolidate project validation reports.	Integrate results of exercises. Build cases. Produce project validation report. Pass results up to programme level. Train participants (where required).	Identify validation exercise shortcomings. Produce exercise validation report(s). Pass results up to project level.

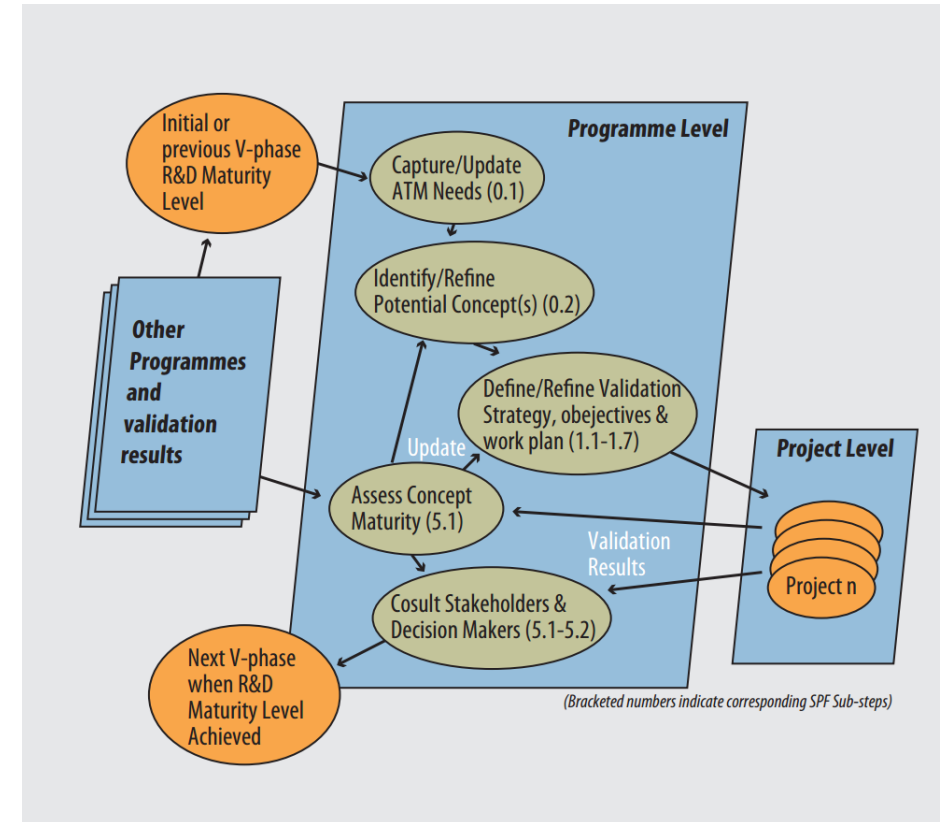
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Programme Level

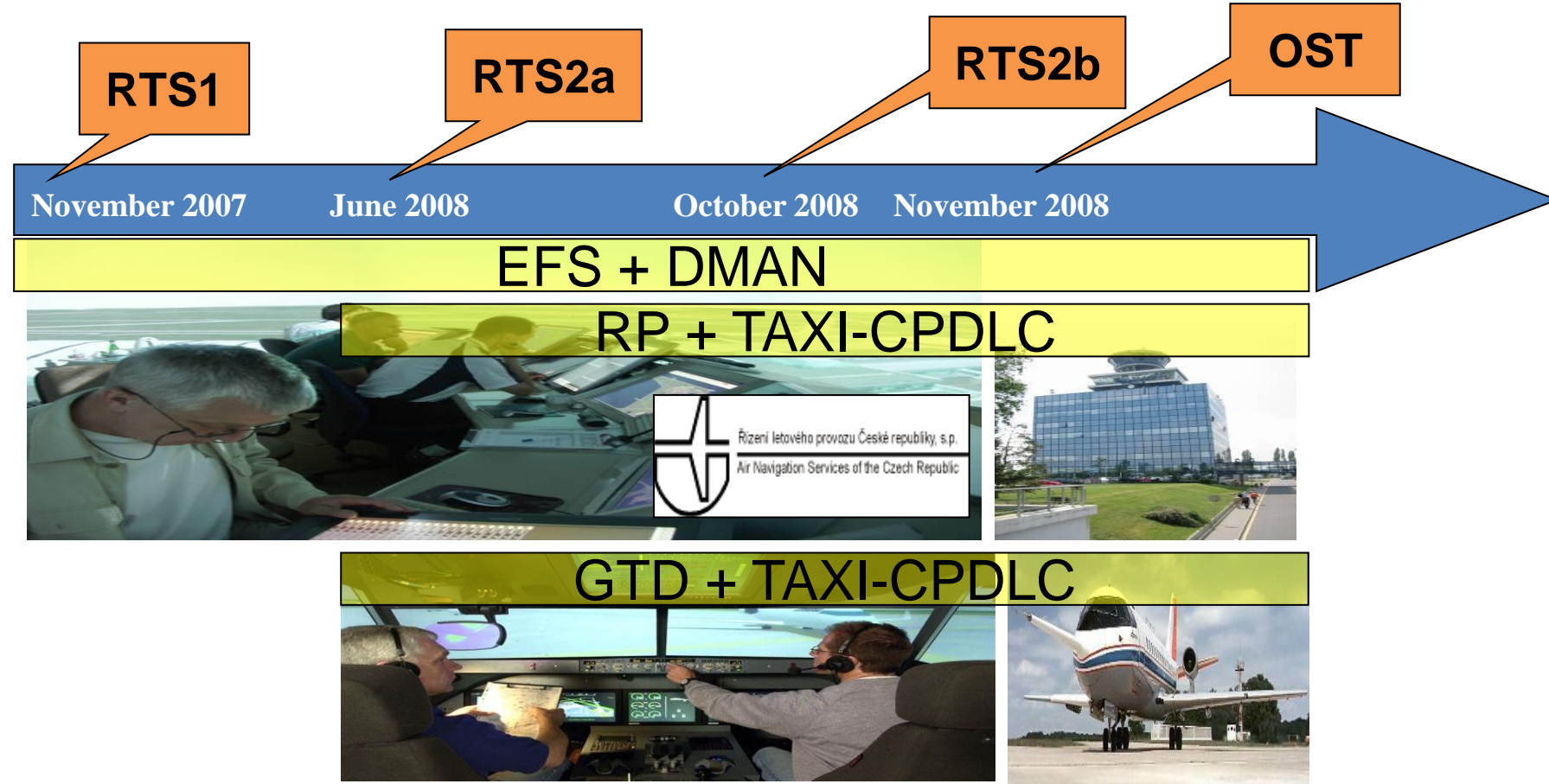
structured planning framework

5. Disseminate Information to Stakeholders	5.1	Review maturity and validation results with stakeholders.	Carry out maturity assessment of the concept(s) or concept elements, when required. Stakeholder review of consolidated programme-level validation results, including case reports.		
	5.2	Draw conclusions and decide on actions, feedback to the validation strategy.	Identify changes to operational concept(s) and validation strategy. If maturity transition criteria achieved for the operational concept (or a specific sub-element), proceed to next V-phase. If not, revise validation plans, e.g. repeat current CLM phase or stop.		



Finally

- More than 40 test runs with 55 movements (duration: 60 minutes)
- Subjects: 7 ATCOs and 11 airline pilots in RTS and OST



Thank you!

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Knowledge for Tomorrow

